I CLAIM:

1. A Polymer Electrolyte Membrane (PEM) fuel cell Membrane Electrode Assembly (MEA) apparatus comprising:

a conductive planar substrate having a front surface and an opposing back surface, the planar substrate also having a porous region;

catalyst material affixed to at least said back surface of said porous region;

polymer electrolyte material affixed to said front surface of said planar substrate, the polymer electrolyte material having an anode surface and an opposing cathode surface;

an anode conductor coupled with said anode surface of said polymer electrolyte material;

a gas-diffusion electrode affixed to said anode conductor; and

a cathode conductor electrically coupled to the conductive substrate through an opening in the polymer electrolyte material.

2. An MEA according to claim 1 further comprising a layered stack of catalyst and palladium disposed between said front surface of said porous region of said planar substrate and said polymer electrolyte material.

3. An MEA according to claim 1 further comprising a transition layer disposed between said polymer electrolyte material and said anode conductor for improving catalysis of fuel.

4. An MEA according to claim 1 further comprising a water barrier adjacent to said back surface catalyst material.

5. An MEA according to claim 1 wherein said anode conductor and said cathode conductor are coplanar.

6. An MEA according to claim 1 wherein said polymer electrolyte material is less than approximately 30 microns thick.

7. An MEA according to claim 1 wherein said polymer electrolyte material is less than approximately 5 microns thick.

8. An MEA according to claim 1 wherein said polymer electrolyte material is less than approximately 1 micron thick.

9. An MEA according to claim 1 wherein said polymer electrolyte material comprises a perfluorocarbon copolymer proton-conducting material.

10. An MEA according to claim 1 wherein said polymer electrolyte material comprises NAFION, a registered trademark of I.E. DuPont Nemours and Company.

11. An MEA according to claim 1 wherein said catalyst material comprises one or more metals chosen from the group consisting of platinum, iridium, palladium, rhodium, molybdenum, gold, and nickel.

12. An MEA according to claim 1 wherein said catalyst material comprises platinum.

13. An MEA according to claim 1 wherein said catalyst material comprises an alloy of platinum and rhodium.

14. An MEA according to claim 1 wherein said substrate comprises silicon.

15. An MEA according to claim 1 wherein said substrate comprises a conductive silicon layer on sapphire.

16. An MEA according to claim 1 wherein said substrate comprises one or more semiconductor compound selected from the group known as the III-V family.

17. An MEA according to claim 1 further comprising a fuel cell body operably connected to said MEA portion.

18. An MEA according to claim 1 further comprising an electronic circuit portion of said substrate and operably coupled to said anode conductor and said cathode conductor.

19. An MEA according to claim 18 wherein said electronic circuit is integral with said membrane electrode assembly.

20. An integrated circuit based fuel cell apparatus comprising:

a Polymer Electrolyte Membrane (PEM) fuel cell Membrane Electrode Assembly (MEA); and

an integrated circuit operably coupled to said membrane electrode assembly.

21. An integrated circuit based fuel cell apparatus according to claim 20 wherein said integrated circuit comprises a fuel cell control circuit.

22. An integrated circuit based fuel cell apparatus according to claim 20 wherein said integrated circuit comprises a driven device.

23. An integrated circuit based fuel cell apparatus according to claim 20 further comprising a fuel cell body operably connected to said MEA.

24. An integrated circuit based fuel cell apparatus according to claim 20 further comprising a planar substrate.

25. An integrated circuit based fuel cell apparatus according to claim 24 wherein said MEA further comprises a porous region of said planar substrate.

26. An integrated circuit based fuel cell apparatus according to claim 24 wherein said planar substrate comprises silicon.

27. An integrated circuit based fuel cell apparatus according to claim 24 wherein said planar substrate comprises a conductive silicon layer on sapphire.

28. An integrated circuit based fuel cell apparatus according to claim 24 wherein said substrate comprises one or more semiconductor compound selected from the group known as the III-V family.

29. An integrated circuit based fuel cell apparatus according to claim 20 wherein said polymer electrolyte material comprises a perfluorocarbon copolymer proton-conducting material.

30. An integrated circuit based fuel cell apparatus according to claim 20 wherein said polymer electrolyte material comprises NAFION, a registered trademark of I.E. DuPont Nemours and Company.

31. An integrated circuit based fuel cell apparatus according to claim 20 wherein said polymer electrolyte material is less than approximately 30 microns thick.

32. An integrated circuit based fuel cell apparatus according to claim 20 wherein said polymer electrolyte material is less than approximately 5 microns thick.

33. An integrated circuit based fuel cell apparatus according to claim 20 wherein said polymer electrolyte material is less than approximately 1 micron thick.

34. An integrated circuit based fuel cell apparatus according to claim 20 wherein said MEA further comprises a catalyst comprising one or more metals selected from the group platinum, iridium, palladium, rhodium, molybdenum, gold, and nickel.

35. An integrated circuit based fuel cell apparatus according to claim 20 wherein said MEA further comprises a catalyst further comprising platinum.

36. An integrated circuit based fuel cell apparatus according to claim 20 wherein said MEA further comprises a catalyst further comprising an alloy of platinum and rhodium.

37. An integrated circuit comprising:

a substrate having a Polymer Electrolyte Membrane (PEM) fuel cell Membrane Electrode Assembly (MEA) portion further comprising:

a porous region of said planar substrate having a front surface and an opposing back surface;

catalyst material affixed to said back surface and sidewalls of said porous region;

polymer electrolyte material affixed to said front surface of planar substrate, the polymer electrolyte material having an anode surface and an opposing cathode surface;

an anode conductor coupled with said anode surface of said polymer electrolyte material;

a gas-diffusion electrode affixed to said anode conductor;

a cathode conductor electrically coupled with said conductive portion of substrate wherein said cathode conductor is coplanar in relation to said anode conductor; and

said substrate also having an integrated circuit portion operably coupled to said MEA portion.

38. An integrated circuit according to claim 37 wherein said integrated circuit portion comprises a fuel cell control circuit.

39. An integrated circuit according to claim 37 wherein said integrated circuit portion comprises a driven device.

40. An integrated circuit according to claim 37 further comprising a fuel cell body operably connected to said MEA portion.

41. An integrated circuit according to claim 37 wherein said planar substrate comprises silicon.

42. An integrated circuit according to claim 37 wherein said planar substrate comprises silicon and sapphire.

43. An integrated circuit according to claim 37 wherein said substrate comprises one or more semiconductor compound selected from the group known as the III-V family.

44. An integrated circuit according to claim 37 wherein said polymer electrolyte material comprises a perfluorocarbon copolymer proton-conducting material.

45. An integrated circuit according to claim 37 wherein said polymer electrolyte material comprises NAFION, a registered trademark of I.E. DuPont Nemours and Company.

46. An integrated circuit according to claim 37 wherein said polymer electrolyte material is less than approximately 30 mils thick.

47. An integrated circuit according to claim 37 wherein said polymer electrolyte material is less than approximately 5 mils thick.

48. An integrated circuit according to claim 37 wherein said polymer electrolyte material is less than approximately 1 mil thick.

49. An integrated circuit according to claim 37 wherein said catalyst comprises one or more metals selected from the group platinum, iridium, palladium, gold, and nickel.

50. An integrated circuit according to claim 37 wherein said catalyst comprises platinum.

51. An integrated circuit according to claim 37 wherein said catalyst comprises an alloy of platinum and rhodium.

52. An integrated circuit according to claim 37 further comprising a layered stack of catalyst and palladium disposed between said front surface of said porous region of said planar substrate and said polymer electrolyte material.

53. An integrated circuit according to claim 37 further comprising a transition layer disposed between said polymer electrolyte material and said anode conductor for lowering lateral electrical resistance.

54. An integrated circuit according to claim 37 further comprising a water barrier adjacent to said back surface catalyst material.